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(54) **CERAMIC HONEYCOMB STRUCTURE**

(57) A ceramic honeycomb structure (1) constituted by cell walls (ribs) (2) forming a composite structure from a plurality of cells (3) being adjacent each other and a honeycomb outer wall (4) surrounding and holding the outermost peripheral cells located at the circumference of the composite structure; said composite structure satisfying the followings:

the basic thickness of the cell walls (2) (the basic cell wall thickness) (Tc) is Tc $\leqq$ 0.12 mm, the outer wall thickness (Ts) of the honeycomb structure is Ts $\geqq$ 0.05 mm, and the open frontal area (P) is P $\geqq$ 80%, and there is a relation shown by formula:

$$1.10 \leqq (Tr_1 \sim Tr_{3-20})/Tc \leqq 3.00$$

between the basic cell wall thickness (Tc) and each cell wall thickness ($Tr_1 \sim Tr_{3-20}$) of cells existing between an outermost peripheral cell and any cell within a first end cell from a fifth cell to a twentieth cell extending inwardly, taking the outermost peripheral cell as a first staring cell.

FIG.1(a)

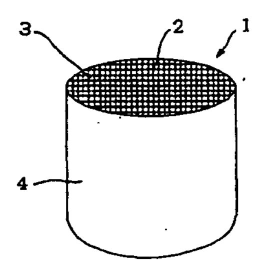
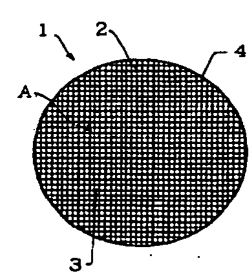


FIG.1(b)



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wall shape and honeycomb structure external shape. That is, a ceramic honeycomb structure is generally molded by extruding, for example, a cordierite raw material for ceramic through a die having lattice-shaped slits; then dried; and fired to become a product. When a smaller cell wall thickness is employed, the cell walls tend to deform during molding, owing to the cause mentioned later and resultantly the fired material obtained showed no satisfactory isostatic strength while this did not happen when the cell wall thickness was as large as 0.15 mm or more. Nevertheless, no sufficient investigation has been made. The deformed cell walls are destroyed at the deformed sites by a small force. That is, when cell walls do not deform and are molded at a high accuracy, they theoretically become sites of compression stress when a pressure is applied to the outer surface of honeycomb structure, and the destruction of honeycomb structure takes place owing to the buckling of cell wall or outer wall. Meanwhile, when cell walls have deformed, a bending stress (a stress in tensile direction) is generated at the deformed sites, resulting in easy destruction. In general, materials are less resistant to tensile strength than to compression stress and, in ceramic materials, in particular, the ratio (about 1/10) of tensile strength to compression strength is very small as compared with that (about 1/3) of metal materials. Therefore, when there is deformation of cell walls, destruction takes place at a strength considerably lower than a strength at which destruction takes place ordinarily.

[0014] The present invention has bee made in view of the above problems, and aims at providing a ceramic honeycomb structure capable of balancing the disadvantages incurred by the increased pressure loss and the decreased thermal shock resistance against the advantages brought about by the increased isostatic strength and the cell wall shape and honeycomb external shape of higher accuracy, and which is suitable particularly as, for example, a carrier for catalyst for automobile exhaust gas purification.

Disclosure of the Invention

[0015] In order to achieve the above object, the present inventor made a study including various tests mentioned later, with considering the thinner cell walls recently employed in honeycomb carriers. As a result, the following was found out. That is, the adoption of a thick wall only in the cells near the circumference of honeycomb structure as seen in the prior art is insufficient and attention must be paid also to the extrudability of honeycomb structure; therefore, the designing of a honeycomb structure need be made while paying attention not only to the relation between the wall thickness of each outermost peripheral cell and the wall thickness of inner cells (basic cells), i.e. the basic cell wall thickness, but also, while considering the basic cell wall thickness and the thickness of honeycomb outer wall, to the relation between the basic cell wall thickness and the wall thickness of the cells existing between the outermost peripheral cell taken as starting cell and any cell taken as end cell of a certain number of cells extending inwardly from the starting cell and located near the circumference of honeycomb structure; by making the designing of a honeycomb structure as above, the above-mentioned aim of the present invention can be achieved. The present invention has been completed based on the above finding.

[0016] It has heretofore been believed that a honeycomb structure having a high strength against a pressure applied to the outer surface can be obtained by allowing the honeycomb structure to have an increased outer wall thickness. There were produced cordierite-made thin wall honeycomb structure samples having an outer diameter of 90 mm, a length of 110 mm, a square cell shape, a cell wall thickness of 0.11 mm and a cell density of 9.3×10^5 cells/m^2 (wall-to-wall distance: 1.04 mm), with varying the outer wall thickness between 0.1 and 0.9 mm; and they were measured for isostatic strength and the results are shown in Fig. 5. As shown in Fig. 5, the isostatic strength showed no increase and reversely decreased, even if the outer wall thickness was made thicker than 0.4 mm.

[0017] The reason for the fact that mere increase in outer wall thickness gives no increase in isostatic strength, is considered to be that as the outer wall thickness is increased, the amount of shape deformation of the wall (rib) of the cells near the circumference of honeycomb structure increases and moreover the number of the deformed walls increases. This is considered to be because as the outer wall thickness is increased, the amount of the raw material passing, during extrusion molding, through the die slit for outer wall formation increases and, as a result, the ribs of the cells near the circumference of honeycomb structure are dragged toward the outer wall and the raw material flow in outer wall and the raw material flow in ribs become unbalanced. The main reasons therefor are considered to be that the change of ribs to smaller thickness incurs easy buckling deformation and that, when the honeycomb structure after extrusion molding is fixed by a jig at the outer surface, the honeycomb structure per se deforms owing to the own weight and, as a result, deformation of the outer wall and the inside ribs, particularly the ribs near the circumference of honeycomb structure takes place. This tendency is considered to be higher as the ribs are thinner and the structure is bigger.

[0018] According to strength of materials, buckling strength is basically proportional to the square of cell wall (rib) thickness, as shown by the following formula. It is appreciated from the formula that the thickness of cell wall has a great influence on the strength of honeycomb carrier.

have a sectional shape of a spool, the thickness of said each cell wall was made thinner as said each cell wall was located more inwardly, and the thinnest wall thickness was made identical to the basic cell wall thickness (Tc) (case 3); when the ratio of the outermost peripheral cell wall thickness (Tr_1) to the basic cell wall thickness (Tc) was set at 2.0, each cell wall of the 2nd and later cells was allowed to have a sectional shape of an inverse trapezoid (the minor base was present inwardly), the thickness of said each cell wall was made thinner as said each cell wall was located more inwardly, the smallest wall thickness was made identical to the basic cell wall thickness, and measurement of pressure loss (%) was made (case 4); and when the ratio of the outermost peripheral cell wall thickness (Tr_1) to the basic cell wall thickness (Tc) was set at 2.0, each cell wall of the 2nd and later cells was allowed to have a sectional shape of a spool, the thickness of said each cell wall was made smaller as said each cell wall was located more inwardly, the thinnest wall thickness was made identical to the basic cell wall thickness, and measurement of pressure loss (%) was made (case 5). As seen from Fig. 11, pressure loss is large in the cases 1 to 3; therefore, when increase in pressure loss is a disadvantage, it is preferred to make gradually smaller the cell wall thickness from the outermost peripheral cell toward inner cells as in the cases 4 and 5.

[0028] Fig. 12 shows the results obtained when, in the cases of Fig. 11, thermal shock resistance (%) was measured in place of pressure loss. As seen from Fig. 12, when the cell wall thickness was made gradually smaller from the predetermined cell to a particular inner cell as in the cases 2 to 5, an increase in thermal shock resistance can be obtained as compared with the case 1.

[0029] Fig. 13 shows the results obtained when pressure loss (%) was measured by setting, at 2.0, the ratio of each cell wall thickness ($Tr_1 \sim Tr_{30}$) of the cells existing between the outermost peripheral cell taken as a starting cell and any cell extending therefrom to the 30th cell, to the basic cell wall thickness (Tc), i.e. $[(Tr_1 \sim Tr_{30})/(Tc)]$. As seen from Fig. 13, pressure loss increases from when the number of cells of thickened wall exceeds 20.

[0030] Fig. 14 shows the results obtained when external shape accuracy (mm) was measured by. setting one by one, at 1.6, the ratio of each cell wall thickness ($Tr_1 \sim Tr_{20}$) of the cells existing between the outermost peripheral cell taken as a starting cell and any cell extending therefrom to the 20th cell, to the basic cell wall thickness (Tc), i.e. $[(Tr_1 \sim Tr_{20})/(Tc)]$. As seen from Fig. 14, external shape accuracy (dimensional accuracy) increases from when the number of cells of thickened wall exceeds 5 and, when the cell walls of up to the 15th cells are made thicker, the dimensional accuracy is half of when the cell wall thickness is constant and the same as the basic cell wall thickness. The reason is considered to be that the thicker wall thickness adopted in the cells near the circumference of honeycomb structure increased the rigidity of the structure and the deformation occurring from structure molding to its firing was suppressed. It is considered that this also contributes to the improvement in the uniform molding.

[0031] Based on the results of the above study, there is provided the following ceramic honeycomb structure according to the present invention.

[1] A ceramic honeycomb structure (1) constituted by cell walls (ribs) (2) forming a composite structure from a plurality of cells (3) being adjacent each other and a honeycomb outer wall (4) surrounding and holding the outermost peripheral cells located at the circumference of the composite structure;

characterized in that a basic thickness of cell walls (2) (the basic cell wall thickness) (Tc) is $Tc \leqq 0.12$ mm, an outer wall thickness (Ts) of the honeycomb structure is $Ts \geqq 0.05$ mm, and an open frontal area (P) is $P \geqq 80\%$, and there is a relation shown by a formula:

$$1.10 \leqq (Tr_1 \sim Tr_{3\text{-}20})/Tc \leqq 3.00$$

between the basic cell wall thickness (Tc) and each cell wall thickness ($Tr_1 \sim Tr_{3\text{-}20}$) of cells existing between an outermost peripheral cell and any cell within a first end cell from a fifth cell to a twentieth cell extending inwardly, taking the outermost peripheral cell as a first staring cell.

[2] A ceramic honeycomb structure according to the above [1], wherein there is a relation shown by a formula:

$$1.10 \leqq (Tr_1 \sim Tr_{3\text{-}15})/Tc \leqq 3.00$$

between the basic cell wall thickness (Tc) and each cell wall thickness ($Tr_1 \sim Tr_{3\text{-}15}$) of cells existing between an outermost peripheral cell and any cell within a first end cell from a third cell to a fifteenth cell extending inwardly, taking the outermost peripheral cell as a first staring cell.

[3] A ceramic honeycomb structure according to the above [1] or [2], wherein any cell within a second end cell from a third cell to a fifth cell extending inwardly, taking a cell adjacent to the first end cell but located inward therefrom as a second starting cell, has such a cell wall thickness that a section of said each cell wall has a rectangular shape whose minor side of rectangle is a cell wall thickness thereof when the honeycomb structure is

$$1.10 \leqq (Tr_1 \sim Tr_{10\text{-}40})/Tc \leqq 3.00$$

between the basic cell wall thickness (Tc) and each cell wall thickness ($Tr_1 \sim Tr_{10\text{-}40}$) of cells existing within a first end cell from a third cell to a fortieth cell extending inwardly, taking the outermost peripheral cell as a first starting cell.

[12] A ceramic honeycomb structure according to any of the above [1] to [10], wherein the honeycomb outer wall has a diameter of 144 mm or more when it has a circular sectional shape and, when it has other than a circular sectional shape, it has a sectional area equal to when it has a circular sectional shape, and there is a following relation shown by a formula:

$$1.10 \leqq (Tr_1 \sim Tr_{10\text{-}30})/Tc \leqq 3.00$$

between the basic cell wall thickness (Tc) and each cell wall thickness ($Tr_1 \sim Tr_{10\text{-}30}$) of cells within a first starting end cell from a tenth cell to a thirtieth cells extending inwardly, taking the outermost peripheral cell as a first starting cell.

[13] A ceramic honeycomb structure according to any of the above [1] to [12], wherein the cell walls and the honeycomb outer wall are made of at least one kind of materials selected from the group consisting of cordierite, alumina, mullite, silicon nitride, aluminum titanate (AT), zirconia and silicon carbide.

[14] A ceramic honeycomb structure according to any of the above [1] to [13], which is used as a carrier for catalyst for automobile exhaust gas purification.

[15] A ceramic honeycomb structure according to any of the above [1] to [14], which is assembled into a catalytic converter by loading a catalyst component on the cell walls and holding the honeycomb outer wall at the outer surface.

[16] A ceramic honeycomb structure according to any of the above [1] to [15], wherein the corners of each cell are formed so as to have a radius of curvature of 1.2 mm or less.

A ceramic honeycomb structure according to any of the above [1] to [16], wherein each intersection between each outermost peripheral cell wall and the honeycomb outer wall is formed so as to have a radius of curvature of 1.2 mm or less.

[18] A ceramic honeycomb structure according to any of the above [1] to [17], wherein there is cell deformation and, when a diameter of the honeycomb structure is 120 mm or less, a first or third end cell is any of a third cell to a fifth cell and, when a diameter is more than 120 mm, a first or a third end cell is any of a sixth cell to a twentieth cell.

[19] A ceramic honeycomb structure according to any of the above [1] to [18], wherein there is provided with a corrugated cell wall having a corrugation in the direction of the cells (passages) between at least one pair of cells adjacent to each other, of the cells from the first starting cell to the first end cell or from the second starting cell to the second end cell or from the third starting cell to the third end cell.

[0032] As described above, the present invention can provide a ceramic honeycomb structure wherein the disadvantages incurred by the increased pressure loss and the decreased thermal shock resistance and the advantages brought about by the increased isostatic strength and the cell wall shape and honeycomb external shape of higher accuracy are balanced appropriately and which is suitably used, for example, as a carrier for catalyst for automobile exhaust gas purification.

Brief Description of the Drawings

[0033]

Fig. 1(a) is a perspective view schematically showing an example of the ceramic honeycomb structure of the present invention. Fig. 1(b is a plan view schematically showing an example of the ceramic honeycomb structure of the present invention.

Fig. 2(a) is a partly enlarged view of the portion A of Fig. 1(b) Fig. 2(b) is a further enlarged view of Fig. 2(a).

Fig. 3(a) is a sectional view schematically showing an example according to the ceramic honeycomb structure of the present invention, wherein any cell within a second end cell from a third cell to a fifth cell extending inwardly, taking a cell adjacent to the first end cell but located inward therefrom as a second starting cell, has such a cell wall thickness that a section of said each cell wall has such an inverse trapezoidal shape as a minor base of inverse trapezoid is a thickness of said each cell wall when the honeycomb structure is cut by a plane perpendicular to

dicular to the cell (passage) direction was allowed to have such a spool shape as the inner side of spool was shorter than the outer side and was the thickness of said each cell wall, the inner side of spool was made shorter as said each cell wall was more inward, the thickness of the cell wall having the shortest inner side was made identical to the basic cell wall thickness (Tc), and pressure loss (%) was measured.

Fig. 12 is a graph showing the results obtained when, in the cases of Fig. 11, thermal shock resistance (%) was measured in place of pressure loss.

Fig. 13 is a graph showing the results obtained when pressure loss (%) was measured by setting, at 2.0, the ratio of each cell wall thickness ($Tr_1 \sim Tr_{30}$) of the cells existing between the outermost peripheral cell taken as a starting cell and any cell extending therefrom to the 30th cell, to the basic cell wall thickness, i.e. [($Tr_1 \sim Tr_{30}$)/(Tc)].

Fig. 14 is a graph showing the results obtained when external shape accuracy (mm) was measured by setting, at 1.6, the ratio of each cell wall thickness ($Tr_1 \sim Tr_{20}$) of the cells existing between the outermost peripheral cell taken as a starting cell and any cell extending therefrom to the 20th cell, to the basic cell wall thickness, i.e. [($Tr_1 \sim Tr_{20}$) /(Tc)].

Fig. 15 is a drawing schematically showing an idea of cell deformation.

Fig. 16 is a drawing showing a relation between the diameter of ceramic honeycomb structure and strength increase.

Fig. 17 is a perspective view schematically showing a corrugated cell wall having a corrugation in the cell (passage) direction.

Fig. 18 is a drawing schematically showing the tester used in measurement of isostatic strength.

Fig. 19 is a graph showing the cold-hot cycle of 1,200°C x cycles used in the test method for measurement of isostatic strength.

Best Mode for Carrying Out the Invention

[0034] Specific description is made below on the best mode for carrying out the present invention.

[0035] As described previously, the ceramic honeycomb structure of the present invention is constituted by cell walls (ribs) forming a composite structure from a plurality of cells being adjacent each other and a honeycomb outer wall surrounding and holding the outermost peripheral cells located at the circumference of the composite structure;

characterized in that a basic thickness of cell walls (the basic cell wall thickness) (Tc) is $Tc \leqq 0.12$ mm, an outer wall thickness (Ts) of the honeycomb structure is $Ts \geqq 0.05$ mm, and an open frontal area (P) is $P \geqq 80\%$, and there is a relation shown by a formula:

$$1.10 \leqq (Tr_1 \sim Tr_{3\text{-}20})/Tc \leqq 3.00$$

between the basic cell wall thickness (Tc) and each cell wall thickness ($Tr_1 \sim Tr_{3\text{-}20}$) of cells existing between an outermost peripheral cell and any cell within a first end cell from a fifth cell to a twentieth cell extending inwardly, taking the outermost peripheral cell as a first staring cell.

[0036] As described above, in the ceramic honeycomb structure of the present invention, the basic cell wall thickness (Tc) of the cell walls constituting the honeycomb structure is 0.12 mm or less, preferably 0.07 mm or less; the honeycomb outer wall thickness (Ts) is 0.05 mm or more, preferably 0.1 mm or more; the open frontal area (P) of_the basic cell portion is 80% or more; and a relation of $1.10 \leqq (Tr_1 \sim Tr_{3\text{-}15})/Tc \leqq 3.00$, preferably $1.10 \leqq (Tr_1 \sim Tr_{5\text{-}15})/Tc \leqq 2.50$, more preferably $1.20 \leqq (Tr_1 \sim Tr_{3\text{-}15})/Tc \leqq 1.60$ is allowed to hold between the basic cell wall thickness (Tc) and each cell wall thickness ($Tr_1 \sim Tr_{3\text{-}15}$) of the cells existing between each outermost peripheral cell (first starting cell) and any cell (first end cell) of the 3rd to 15th cells extending inwardly from the first starting cell. Thereby, a thin wall honeycomb structure can be obtained wherein the disadvantage incurred by the increased pressure loss is balanced against the advantage brought about by the increased isostatic strength are appropriately balanced, and which has an increased isostatic strength and a cell wall shape and honeycomb external shape of higher accuracy.

[0037] The embodiment of the ceramic honeycomb structure of the present invention is described below more specifically with referring to the accompanying drawings.

Fig. 1(a) is a perspective view schematically showing an example of the ceramic honeycomb structure of the present invention, and Fig. 1(b is a plan view thereof. A ceramic honeycomb structure 1 comprises a plurality of parallel passages (cells) 3 separated by cell walls 2. Each outermost peripheral cell of the plurality of cells 3 is surrounded and held by a honeycomb outer wall 4.

Fig. 2(a) is a partly enlarged view of the portion A of Fig. 1(b) and Fig. 2(b) is a further enlarged view of Fig. 2(a). As shown in Figs. 2(a) and 2(b), there is each outermost peripheral cell (first starting cell) 8 in the nearest vicinity of the outer wall 4; and a second cell 9 extends inwardly from the outermost peripheral cell (first starting cell) 8.

when the honeycomb structure is cut by a plane perpendicular to the direction of the cells (passages) and the resulting section of each cell wall of the cells existing from the third staring cell to the third end cell is seen, the section of said each cell wall is allowed to have such a rectangular shape as the minor side is the thickness of said each cell wall, or such an inverse trapezoidal shape as the minor base of inverse trapezoid is present inwardly and is the thickness of said each cell wall. or such a spool shape as the inner side of spool is shorter than the outer side and is the thickness of said each cell wall; the minor side of rectangle, or the inward minor base of inverse trapezoid or the inner side of spool is made shorter as said each cell wall is more inward; and the thickness of the cell wall having the shortest minor side, or the shortest minor base or the shortest inner side is made identical to the basic cell wall thickness (Tc). By constituting the present honeycomb structure as above, improvements in pressure loss and thermal shock resistance can be obtained.

[0045] In the present invention, it is also preferred in view of the pressure loss in practical application that the basic cell wall thickness and each cell wall thickness ($Tr_1 \sim Tr_{3\text{-}20}$) have, as mentioned previously, a more restricted relation of $1.10 \leqq (Tr_1 \sim Tr_{5\text{-}20})/Tc \leqq 2.50$, or an even more restricted relation of $1.20 \leqq (Tr_1 \sim Tr_{3\text{-}20})/Tc \leqq 1.60$.

[0046] As to the sectional shape of cell, used in the present invention, there is no particular restriction. However, a sectional shape of, for example, a triangle or a higher polygon can be mentioned. In particular, any of a square, rectangle and a hexagon is preferred.

[0047] As the sectional shape of honeycomb outer wall, used in the present invention, there can be mentioned, for example, a circle, an ellipse, a trapezoid, a triangle, a square, a hexagon or a special shape whose left and right are asymmetrical to each other. Of these, a circle or an ellipse is preferred.

[0048] In recent years, honeycomb carriers have come to be mounted in large vehicles (e.g. trucks) as well and large-sized honeycomb carriers have become necessary. In the case of such a large-sized honeycomb carrier as having a diameter of 144 mm or more when the sectional shape of honeycomb outer wall is a circle, or, when the sectional shape is other shape, having a sectional area equal to when the sectional shape is a circle, it is preferred that the first end cell counted from the outermost peripheral cell (1st starting cell) is stretched to any of the 10th to 40th cells, preferably the 10th to 30th cells, all extending inwardly from the outermost peripheral cell, that is, the cells of thickened wall are increased and that the ratio of the cell wall thickness ($Tr_1 \sim Tr_{10\text{-}40}$), preferably ($Tr_1 \sim Tr_{10\text{-}30}$) to the basic cell wall thickness (Tc), i.e. $(Tr_1 \sim Tr_{10\text{-}40})/Tc$, preferably $(Tr_1 \sim Tr_{10\text{-}30})/Tc$ is set ordinarily at 1.10 to 3.00 and, in practical application, at 1.10 to 2.50, preferably 1.20 to 1.60.

[0049] As the material for cell wall and honeycomb outer wall, used in the present invention, there can be mentioned, for example, at least one kind of material selected from the group consisting of cordierite, alumina, mullite, silicon nitride, aluminum titanate (AT), zirconia and silicon carbide.

[0050] Fig. 4 is a drawing schematically showing a case in which the honeycomb carrier of the present invention has been accommodated in a catalytic converter container. A honeycomb carrier 13 is held by a ring 12 at the outer surface and accommodated in a converter container 11. There is no particular restriction as to the ring 12, but a metal mesh-made ring is ordinarily used. Between the converter container 11 and the outer surface of the honeycomb carrier 13, a buffer member 14 (e.g. a mat or a cloth) is preferably interposed.

[0051] Next, the present invention is more specifically described by way of Examples. However, the present invention is in no way restricted by these Examples.

[0052] Incidentally, the honeycomb structures obtained in the Examples were evaluated for performance by the following methods.

Isostatic strength test

[0053] The test and evaluation were made according to the JASO standard M 505-87 issued by Society of Automotive Engineer of Japan, Inc. In Table 1, evaluation was made by three grades of no increase (increase was not seen as a significance difference as compared with standard), small increase, and increase.

Thermal shock resistance test

[0054] This is a test in which a honeycomb carrier of room temperature is placed in an electric furnace kept at a temperature higher than room temperature by a given temperature, is kept for 20 minutes, is taken out onto a refractory brick, is observed for appearance, and is lightly tapped by a metal bar at the outer surface. An evaluation of "pass" is given when the carrier appearance shows no crack and a metallic sound (not a thick sound) is heard when tapped. The test is repeated until a "fail" evaluation is reached when the temperature inside the electric furnace is gradually increased by each 50°C. When "fail" is reached at a temperature of 950°C higher than room temperature, the thermal shock resistance of the honeycomb carrier is taken as 900°C difference.

Table 1

Example or Comparative Example	Cell Structure (mil/cpsi)	Basic cell wall thickness (A)	Thickness of thickened cell walls (B)	(B)/(A)	No. of cells of thickened wall	Isostatic strength	Shape accuracy	Pressure loss (hp)	Thermal shock resistance
Comparative example 1	3.0/600	0.075	0.075	1.0	0	Standard	Standard	Standard	Standard
Comparative example 2	3.0/600	0.075	0.100	1.33	2	No increase	Not improved	Small increase	Equivalent to standard
Example 1	3.0/600	0.075	0.100	1.33	5	Small increase	Not improved	Small increase	Equivalent to standard
Example 2	3.0/600	0.075	0.100	1.33	8	Increase	Slightly improved	Increase	Equivalent to standard
Example 3	3.0/600	0.075	0.100	1.33	11	Increase	Improved	Increase	Equivalent to standard
Comparative example 3	3.0/600	0.075	0.080	1.07	13	No increase	Slightly improved	Increase	Equivalent to standard
Example 4	3.0/600	0.075	0.085	1.13	13	Small increase	Slightly improved	Increase	Equivalent to standard
Example 5	3.0/600	0.075	0.090	1.20	13	Small increase	Improved	Increase	Equivalent to standard
Example 6	3.0/600	0.075	0.100	1.33	13	Small increase	Improved	Increase	Equivalent to standard
Comparative example 4	3.0/600	0.075	0.150	2.00	2	No increase	Not improved	Small increase	-
Example 7	3.0/600	0.075	0.150	2.00	5	Small increase	Slightly improved	Increase	-
Example 8	3.0/600	0.075	0.150	2.00	8	Increase	Improved	Increase	-
Example 9	3.0/600	0.075	0.150	2.00	11	Increase	Improved	Increase	-
Example 10	3.0/600	0.075	0.150	2.00	13	Increase	Improved	Increase	-
Comparative example 11	3.0/600	0.075	0.200	2.67	2	No increase	Not improved	-	-
Example 12	3.0/600	0.075	0.200	2.67	5	Small increase	Slightly improved	-	-
Example 13	3.0/600	0.075	0.200	2.67	8	Increase	Improved	-	-
Example 14	3.0/600	0.075	0.200	2.67	11	Increase	Improved	-	-
Example 15	3.0/600	0.075	200	67	13	Increase	Improved	Increase	-
Example 16	3.0/600	0.075	0.225	3.00	13	Increase	-	Increase	-
Comparative Example 5	3.0/600	0.075	0.240	3.20	13	Increase	-	Big increase	-

Table 2

Example or Comparative Example	Cell Structure (mil/cpsi)	Basic cell wall thickness (A)	Thickness of thickened cell walls (B)	(B)/(A)	No. of cells of thickened wall	Isostatic strength	Shape accuracy	Pressure loss (hp)	Thermal shock resistance
Comparative Example 8	2.0/900	0.050	0.050	1.0	0	Standard	Standard	Standard	Standard
Example 26	2.0/900	0.050	0.055	1.1	10	Small increase	Slightly improved	Increase	Equivalent to standard
Example 27	2.0/900	0.050	0.060	1.2	10	Small increase	Improved	Increase	Equivalent to standard
Example 28	2.0/900	0.050	0.065	1.3	10	Small increase	Improved	Increase	Equivalent to standard
Example 29	2.0/900	0.050	0.070	1.4	10	Increase	Improved	Increase	Equivalent to standard
Example 30	2.0/900	0.050	0.075	1.5	10	Increase	Improved	Increase	Equivalent to standard
Example 31	2.0/900	0.050	0.080	1.6	10	Increase	Improved	Increase	Equivalent to standard
Example 32	2.0/900	0.050	0.085	1.7	10	Increase	Improved	Increase	Slight decrease
Example 33	2.0/900	0.050	0.090	1.8	10	Increase	Improved	Increase	Slight decrease
Example 34	2.0/900	0.050	0.100	2.0	10	Increase	Improved	Increase	Decrease
Example 35	2.0/900	0.050	0.125	2.5	10	Increase	Improved	Increase	Decrease
Example 36	2.0/900	0.050	0.150	3.0	10	Increase	Improved	Increase	Slight decrease
Comparative Example 9	2.0/900	0.050	0.175	3.5	10	Increase	Improved	Big increase	Big decrease
Example 37	2.0/900	0.050	0.080	1.6	2	No increase	Not improved	Small increase	Equivalent to standard
Example 38	2.0/900	0.050	0.080	1.6	5	Small increase	Slightly improved	Small increase	Equivalent to standard
Example 39	2.0/900	0.050	0.080	1.6	7	Small increase	Improved	Increase	Equivalent to standard
Example 40	2.0/900	0.050	0.080	1.6	10	Increase	Improved	Increase	Equivalent to standard
Example 41	2.0/900	0.050	0.080	1.6	15	Increase	Improved	Increase	Slight decrease
Example 42	2.0/900	0.050	0.080	1.6	20	Increase	-	Increase	Slight decrease
Comparative Example 10	2.0/900	0.050	0.080	1.6	25	Increase	-	Big increase	Slight decrease

Table 4

Example or Comparative Example	Cell Structure (mil/cpsi)	Basic cell wall thickness (A)	Thickness of thickened cell walls (B)	(B)/(A)	No. of cells of thickened wall	Isostatic strength	Shape accuracy	Pressure loss (hp)	Thermal shock resistance
Comparative Example 19	1.5/900	0.035	0.035	1.0	0	Standard	Standard	Standard	Standard
Example 48	1.5/900	0.035	0.065	1.86	15	Increase	Improved	Increase	Equivalent to standard
Comparative Example 20	2.0/1200	0.050	0.050	1.0	0	Standard	Standard	Standard	Standard
Example 49	2.0/1200	0.050	0.080	1.60	10	Increase	Improved	Increase	Equivalent to standard
Comparative Example 21	1.5/1200	0.035	0.035	1.0	0	Standard	Standard	Standard	Standard
Comparative Example 22	1.5/1200	0.035	0.065	1.86	2	No increase	Not improved	Small increase	Equivalent to standard
Comparative Example 23	1.5/1200	0.035	0.065	1.86	10	Increase	Improved	Increase	Equivalent to standard
Example 50	1.5/1200	0.035	0.065 ~0.035	1.86 Inverse trapezoid-like decrease	15 16-20	Increase	Improved	Increase	Equivalent to standard
Example 51	1.5/1200	0.035	0.065~0.035	Inverse trapezoid-like decrease	30	Increase	Improved	Big increase	Slight decrease
Comparative Example 24	1.0/1200	0.025	0.035	1.0	0	Standard	Standard	Standard	Standard
Example 52	1.0/1200	0.025	0.065 ~0.025	2.6 Inverse trapezoid-like decrease	10 11-20	Increase	Improved	Increase	Equivalent to standard
Comparative Example 25	1.0/1800	0.025	0.035	1.0	0	Standard	Standard	Standard	Standard
Example 53	1.0/1800	0.025	0.065 ~0.025	2.6 Inverse trapezoid-like decrease	10 11-20	Increase	Improved	Increase	Equivalent to standard

an outer wall thickness (Ts) of the honeycomb structure is $Ts \geqq 0.05$ mm, and an open frontal area (P) is $P \geqq 80\%$, and there is a relation shown by a formula:

$$1.10 \leqq (Tr_1 \sim Tr_{3\text{-}20})/Tc \leqq 3.00$$

between the basic cell wall thickness (Tc) and each cell wall thickness ($Tr_1 \sim Tr_{3\text{-}20}$) of cells existing between an outermost peripheral cell and any cell within a first end cell from a fifth cell to a twentieth cell extending inwardly, taking the outermost peripheral cell as a first staring cell.

2. A ceramic honeycomb structure according to Claim 1,
wherein there is a relation shown by a formula:

$$1.10 \leqq (Tr_1 \sim Tr_{3\text{-}15})/Tc \leqq 3.00$$

between the basic cell wall thickness (Tc) and each cell wall thickness ($Tr_1 \sim Tr_{3\text{-}15}$) of cells existing between an outermost peripheral cell and any cell within a first end cell from a third cell to a fifteenth cell extending inwardly, taking the outermost peripheral cell as a first staring cell.

3. A ceramic honeycomb structure according to Claim 1 or 2,
wherein any cell within a second end cell from a third cell to a fifth cell extending inwardly, taking a cell adjacent to the first end cell but located inward therefrom as a second starting cell, has such a cell wall thickness that a section of said each cell wall has a rectangular shape whose minor side of rectangle is a cell wall thickness thereof when the honeycomb structure is cut by a plane perpendicular to the direction of the cells (passages),and
a cell wall thickness having a shortest minor side is identical to the basic cell wall thickness (Tc), by shortening a minor side thereof one by one as a cell is located more inwardly.

4. A ceramic honeycomb structure according to Claim 1 or 2,
wherein any cell within a second end cell from a third cell to a fifth cell extending inwardly, taking a cell adjacent to the first end cell but located inward therefrom as a second starting cell, has such a cell wall thickness that a section of said each cell wall has such an inverse trapezoidal shape as a minor base of inverse trapezoid is a thickness of said each cell wall when the honeycomb structure is cut by a plane perpendicular to the direction of the cells (passages), and
a thickness of a cell wall having a shortest minor base is identical to the basic cell wall thickness (Tc), by shortening a minor base of inverse trapezoid thereof one by one as said each cell wall is located more inwardly.

5. A ceramic honeycomb structure according to Claim 1 or 2,
wherein any cell within a second end cell from a third cell to a fifth cell extending inwardly, taking a cell adjacent to the first end cell but located inward therefrom as a second starting cell, has such a cell wall thickness that a section of said each cell wall has such a spool shape as an inner side of spool is shorter than an outer side when the honeycomb structure is cut by a plane perpendicular to the direction of the cells (passages), and
a thickness of a cell wall having an shortest inner side is identical to the basic cell wall thickness (Tc), by shortening inner side of spool thereof one by one as said each cell wall is located more inwardly.

6. A ceramic honeycomb structure according to Claim 1,
wherein there is a relation shown by a formula

$$1.10 \leqq Tr_1/Tc \leqq 3.00$$

between the cell wall thickness (Tr_1) of each outermost peripheral cell and the basic cell wall thickness (Tc),
there is a relation shown by a formula

$$1.10 \leqq (Tr_1 \sim Tr_{3\text{-}20})/Tc \leqq 3.00$$

between the basic cell wall thickness (Tc) and each cell wall thickness ($Tr_1 \sim Tr_{3\text{-}20}$) within a third end cell from a

mullite, silicon nitride, aluminum titanate (AT), zirconia and silicon carbide.

14. A ceramic honeycomb structure according to any of Claims 1 to 13, which is used as a carrier for catalyst for automobile exhaust gas purification.

15. A ceramic honeycomb structure according to any of Claims 1 to 14, which is assembled into a catalytic converter by loading a catalyst component on cell walls and holding honeycomb outer wall at outer surface.

16. A ceramic honeycomb structure according to any of Claims 1 to 15, wherein corners of each cell are formed so as to have a radius of curvature of 1.2 mm or less.

17. A ceramic honeycomb structure according to any of Claims 1 to 16, wherein each intersection between each outermost peripheral cell wall and the honeycomb outer wall is formed so as to have a radius of curvature of 1.2 mm or less.

18. A ceramic honeycomb structure according to any of Claims 1 to 17, wherein there is cell deformation and, when a diameter of the honeycomb structure is 120 mm or less, a first or third end cell is any of a third cell to a fifth cell and, when a diameter is more than 120 mm, a first or a third end cell is any of a sixth cell to a twentieth cell.

19. A ceramic honeycomb structure according to any of Claims 1 to 18, wherein there is provided with a corrugated cell wall having a corrugation in the direction of the cells (passages) between at least one pair of cells adjacent to each other, of the cells from the first starting cell to the first end cell or from the second starting cell to the second end cell or from the third starting cell to the third end cell.

FIG.2(a)

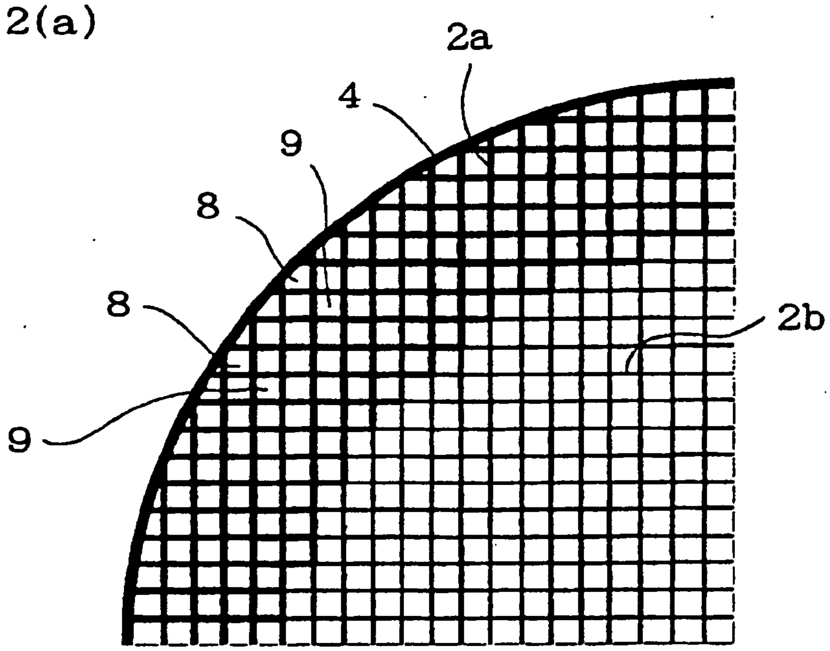


FIG.2(b)

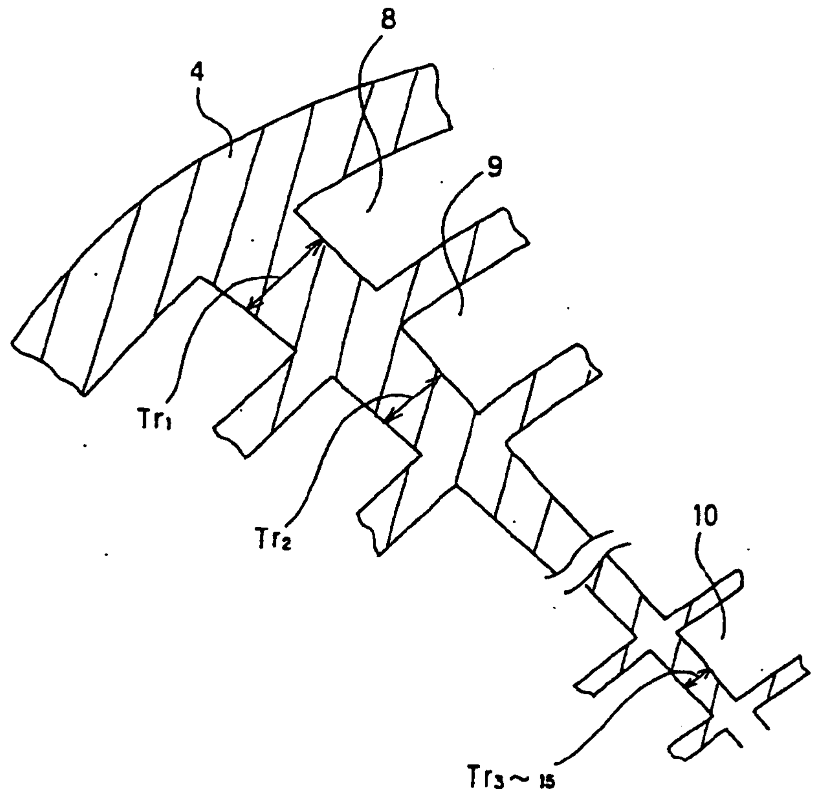


FIG. 5

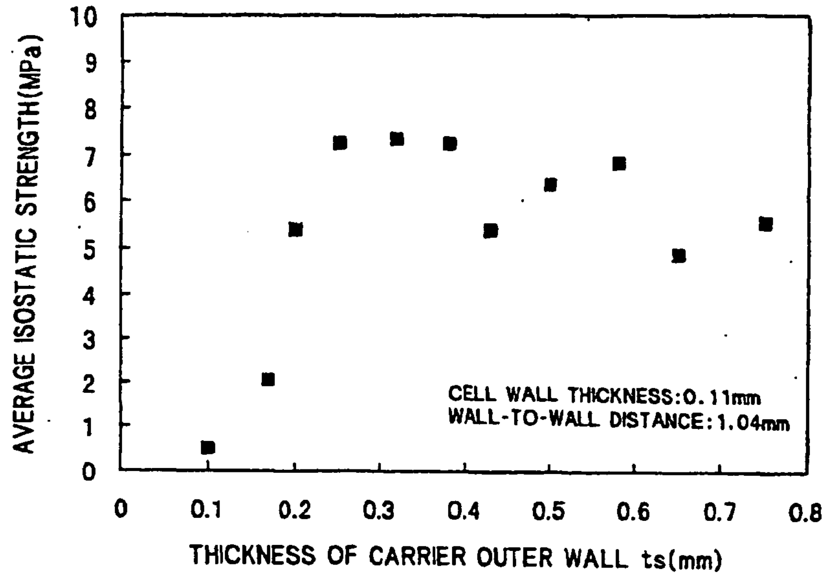

10
9
8
7
6
5
4
3
2
1
0
AVERAGE ISOSTATIC STRENGTH(MPa)
CELL WALL THICKNESS:0.11mm
WALL-TO-WALL DISTANCE:1.04mm
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
THICKNESS OF CARRIER OUTER WALL ts(mm)

FIG. 6

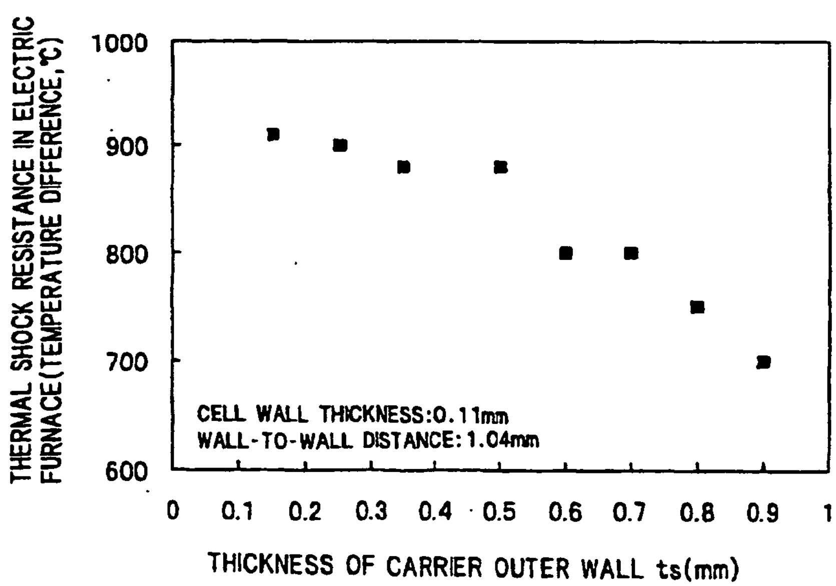

1000
900
800
700
600
THERMAL SHOCK RESISTANCE IN ELECTRIC FURNACE(TEMPERATURE DIFFERENCE,℃)
CELL WALL THICKNESS:0.11mm
WALL-TO-WALL DISTANCE:1.04mm
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
THICKNESS OF CARRIER OUTER WALL ts(mm)

FIG. 8

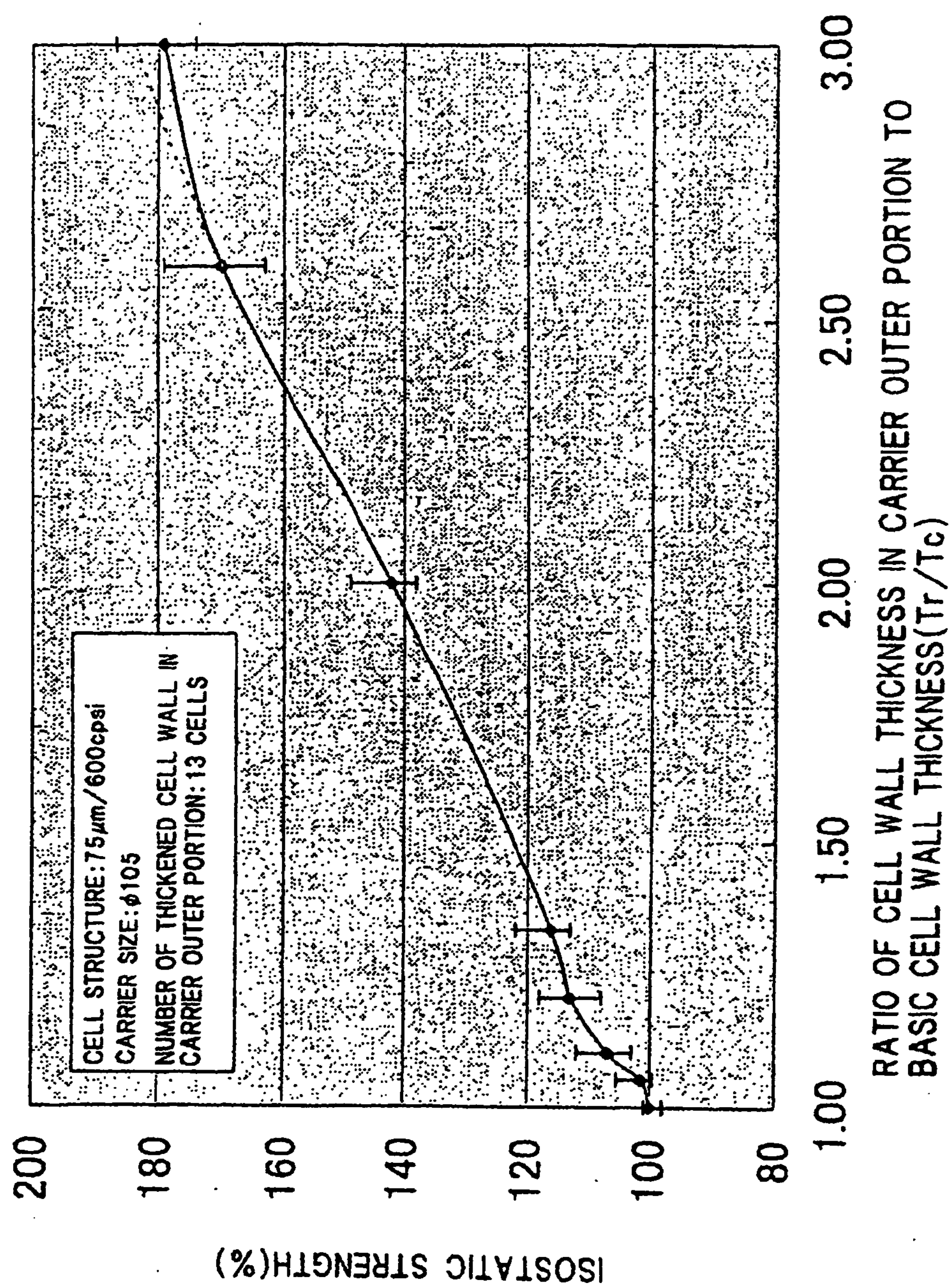

CELL STRUCTURE: 75μm/600cpsi
CARRIER SIZE: φ105
NUMBER OF THICKENED CELL WALL IN CARRIER OUTER PORTION: 13 CELLS
ISOSTATIC STRENGTH(%)
200
180
160
140
120
100
80
1.00
1.50
2.00
2.50
3.00
RATIO OF CELL WALL THICKNESS IN CARRIER OUTER PORTION TO BASIC CELL WALL THICKNESS(Tr/Tc)

FIG.10

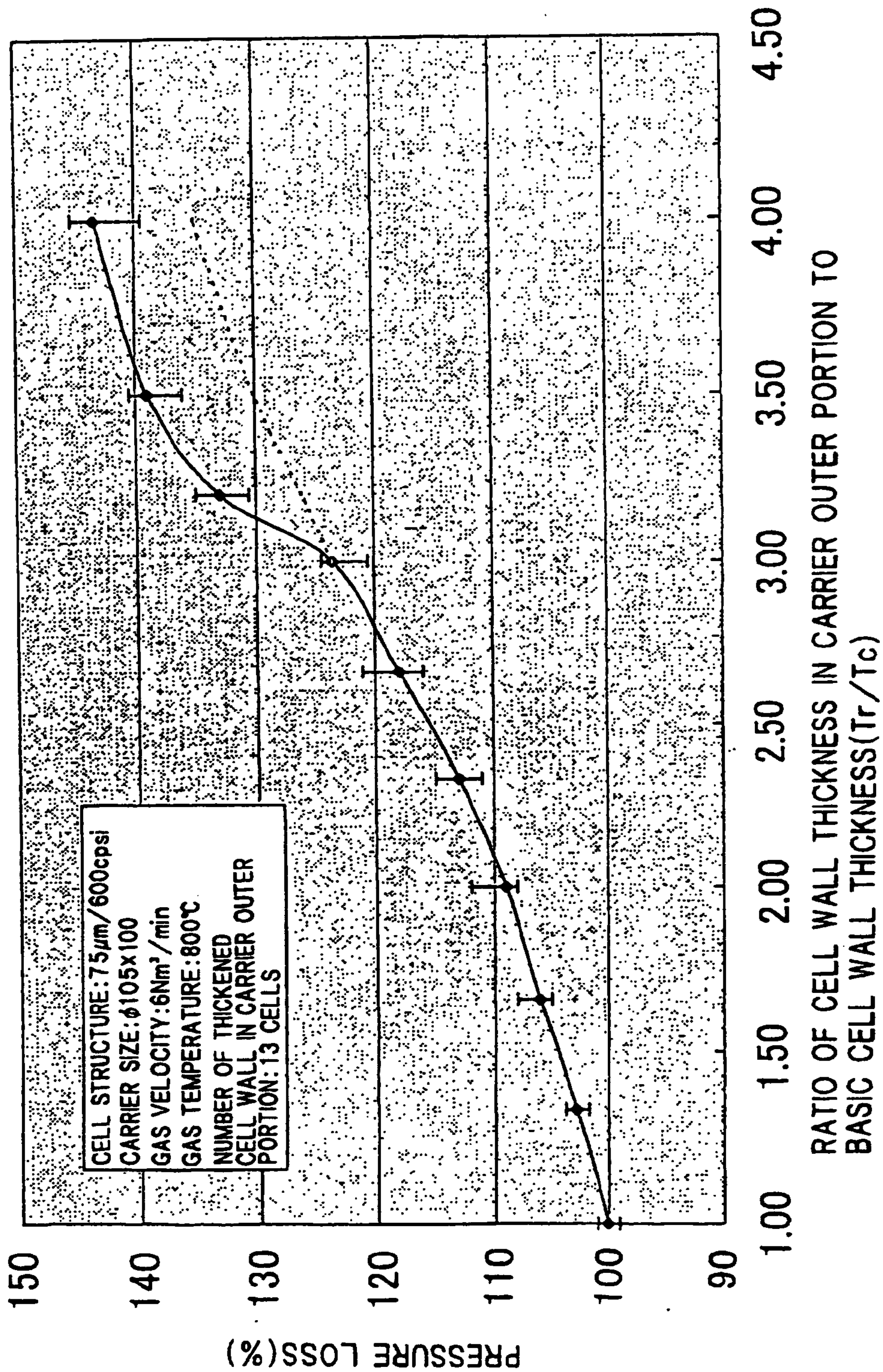

CELL STRUCTURE:75μm/600cpsi
CARRIER SIZE:φ105x100
GAS VELOCITY:6Nm³/min
GAS TEMPERATURE:800℃
NUMBER OF THICKENED CELL WALL IN CARRIER OUTER PORTION:13 CELLS
PRESSURE LOSS(%)
150
140
130
120
110
100
90
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
RATIO OF CELL WALL THICKNESS IN CARRIER OUTER PORTION TO BASIC CELL WALL THICKNESS(Tr/Tc)

FIG.12

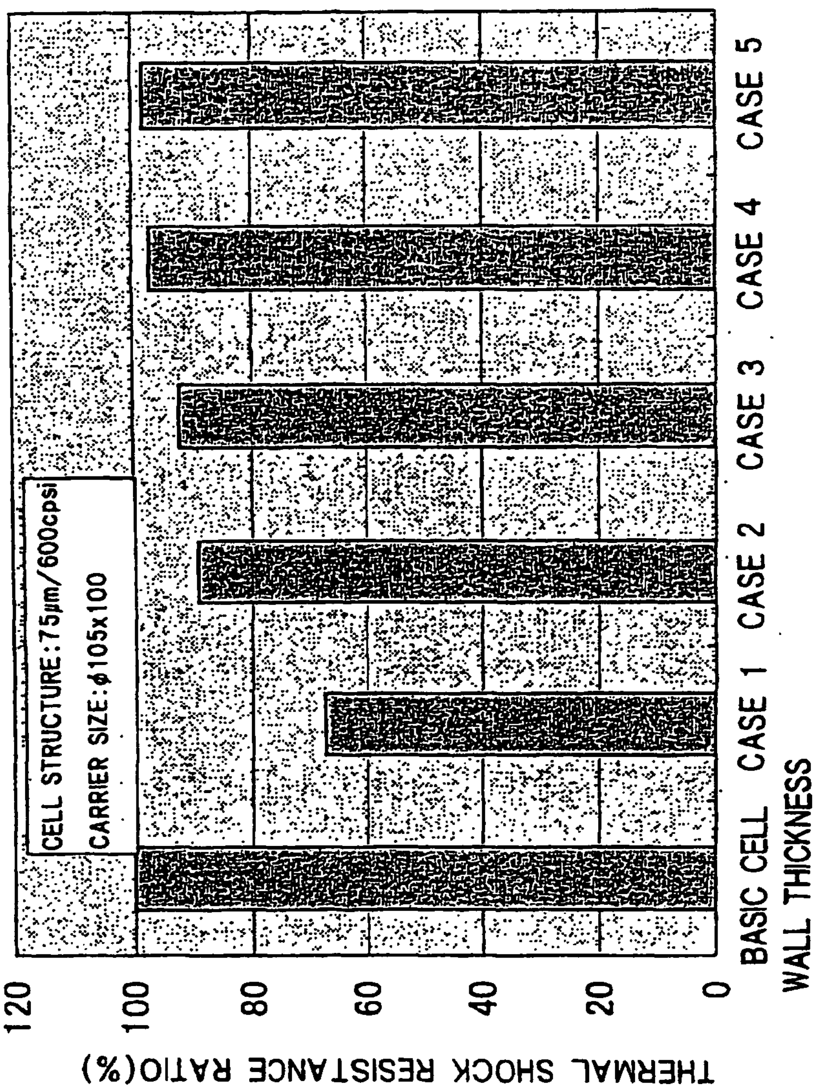

CELL STRUCTURE: 75μm/600cpsi
CARRIER SIZE: φ105x100
THERMAL SHOCK RESISTANCE RATIO(%)
120
100
80
60
40
20
0
BASIC CELL
CASE 1
CASE 2
CASE 3
CASE 4
CASE 5
WALL THICKNESS

FIG.14

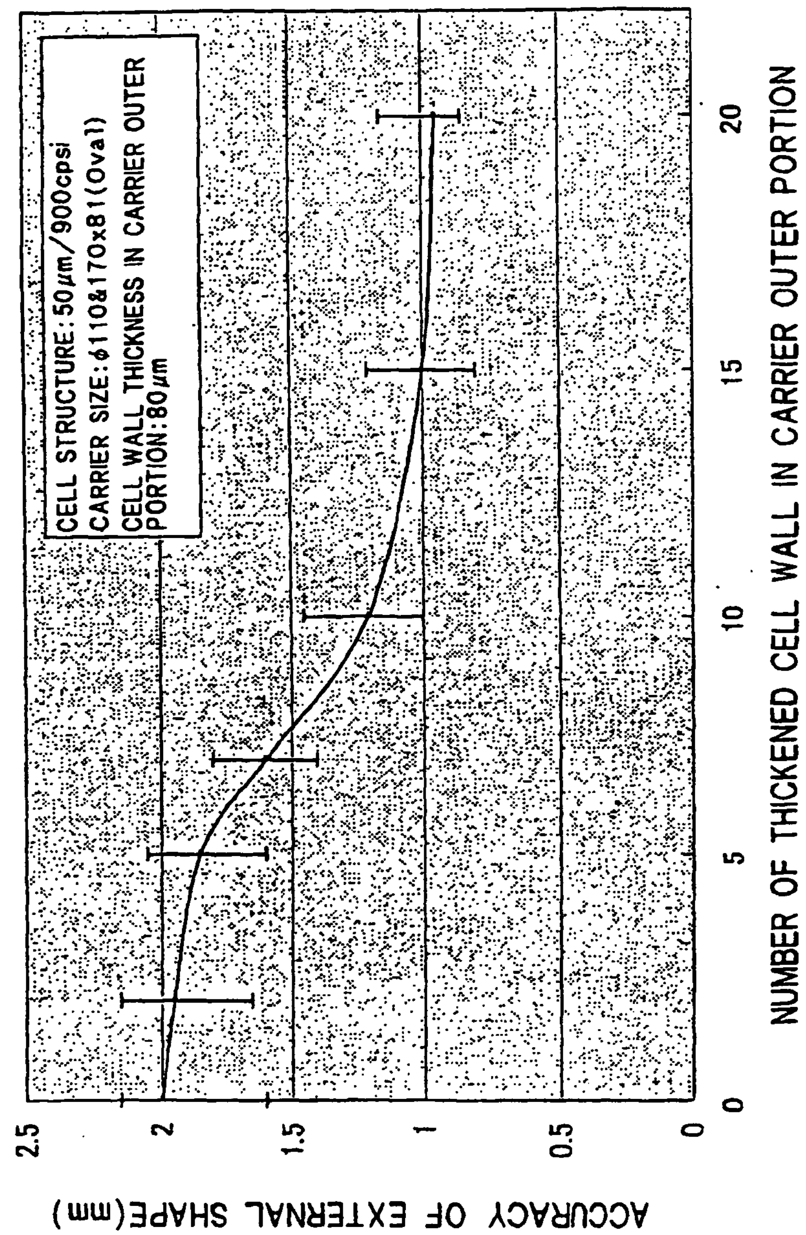

CELL STRUCTURE: 50μm/900cpsi
CARRIER SIZE: φ110&170x81(Oval)
CELL WALL THICKNESS IN CARRIER OUTER PORTION: 80μm
ACCURACY OF EXTERNAL SHAPE(mm)
2.5
2
1.5
1
0.5
0
0
5
10
15
20
NUMBER OF THICKENED CELL WALL IN CARRIER OUTER PORTION

FIG.16

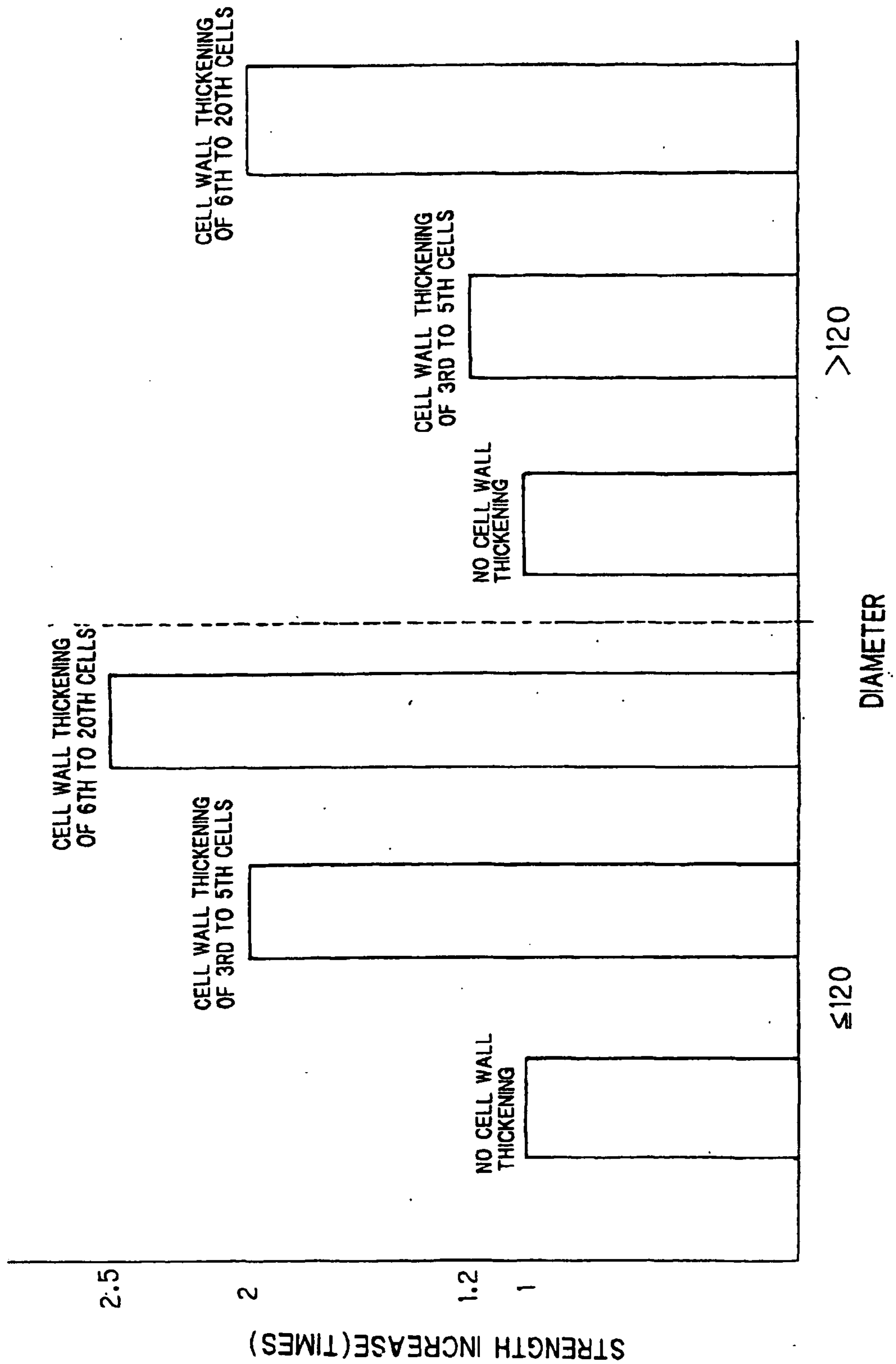

STRENGTH INCREASE(TIMES)
2.5
2
1.2
1
DIAMETER
≦120
>120
NO CELL WALL THICKENING
CELL WALL THICKENING OF 3RD TO 5TH CELLS
CELL WALL THICKENING OF 6TH TO 20TH CELLS
NO CELL WALL THICKENING
CELL WALL THICKENING OF 3RD TO 5TH CELLS
CELL WALL THICKENING OF 6TH TO 20TH CELLS

FIG. 18

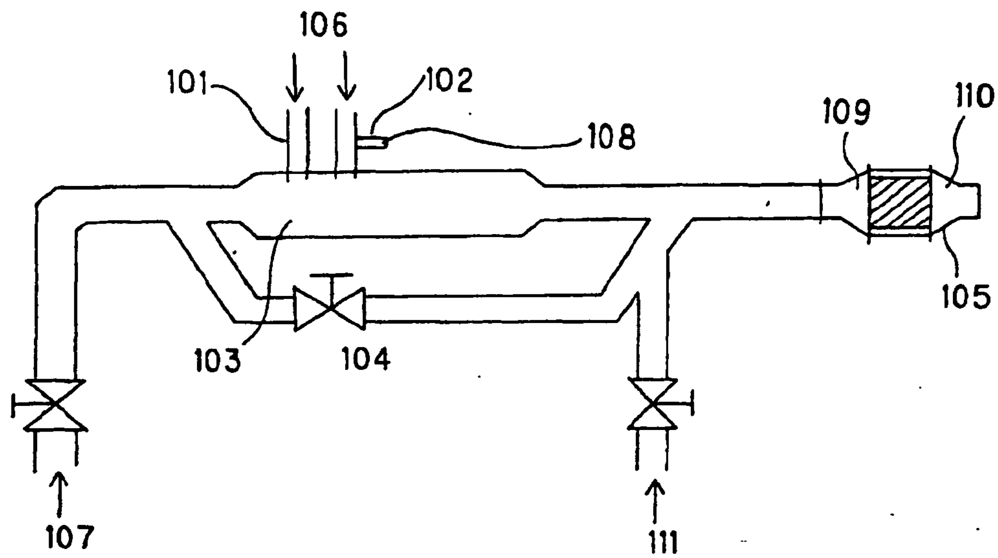
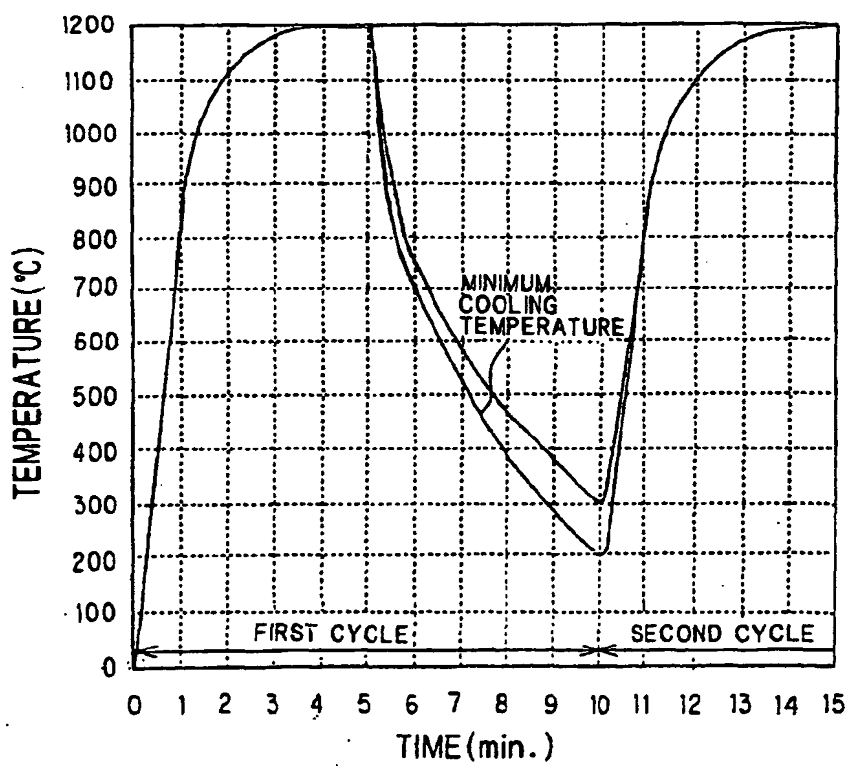

106
101
102
108
109
110
105
103
104
107
111

FIG. 19


TEMPERATURE (°C)
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
MINIMUM COOLING TEMPERATURE
FIRST CYCLE
SECOND CYCLE
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
TIME (min.)